

The Costs and Risks of Medical Care

An Annotated Bibliography for Clinicians and Educators

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Understanding the costs and risks of medical care, as well as the benefits, is essential to good medical practice. The literature on this topic transcends disciplines, making it a challenge for clinicians and medical educators to compile information on costs and risks for use in patient care. This annotated bibliography presents summaries of pertinent references on (1) financial costs of care, (2) excessive use of medical services, (3) clinical risks of care, (4) decision analysis, (5) cost-benefit analyses, (6) factors affecting physician use of services and (7) strategies to improve physician ordering patterns.

. . . good medicine does not consist in the indiscriminate application of laboratory examinations to a patient, but rather in having so clear a comprehension of the probabilities of a case as to know what tests may be of value . . . it should be the duty of every hospital to see that no house officer receives his diploma unless he has demonstrated . . . a knowledge of how to use the results in the study of his patient.

G. W. PEABODY*

INCREASINGLY, clinicians and medical educators must consider the costs of medical care in their practice and teaching. Because physicians control patient care through their clinical decisions, they also greatly influence, if not determine, the costs of care. Financial costs now approach \$300 bil-

lion a year in the United States and are the most widely recognized cost item. Yet other costs of patient care must also be acknowledged. These include the physical discomfort and risks to patients undergoing tests and procedures, and the efficiency costs to hospitals having to meet greatly increasing demands on their resources.

We offer this annotated bibliography as an introduction to the rapidly expanding literature on the costs of medical care and clinical decision making. Originally, it was developed in brief form for an educational seminar on clinical decision making and clinical costs that we are conducting for medical and surgical house officers at the University of California, San Francisco. This expanded bibliography is intended to aid educators teaching about and physicians caring for patients who have been routinely admitted to hospital—those who account for the bulk of medical care costs. It focuses primarily on laboratory, radiological, surgical and pharmaceutical services because these constitute a large proportion of patient bills and are commonly ordered in routine

*Peabody GW: The physician and the laboratory. Boston Med Surg J 1922; 187:324-327

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patient care. In general, the bibliography does not include less frequently ordered hospital services, such as hemodialysis, nor does it review the exceptional "high cost patients," those who require intensive care services or prolonged hospital care.

The articles and books reviewed here were selected to meet five specific criteria. First, they deal primarily with cost and efficiency in clinical situations. The papers selected are clinically relevant, dealing with common patient care situations and routinely ordered tests and procedures. Second, they are aimed at practicing physicians and physician-educators. We believe that physician education should stress better clinical decision making both for patients' sakes and as a means to conserving resources. Several of the references, however, are more likely to provoke thought about the costs of care than they are to guide a clinician's or educator's actions. Third, the articles are methodologically sound, or in a few cases, especially intriguing. Some references in this field have been omitted, either because they duplicate the work of others or because they were less methodologically solid. Fourth, many of these references are guides to more appropriate use of hospital services; as such, they can be used to develop policies for educational or administrative programs to reduce unnecessary use of hospital services. Fifth, the articles and books are readily accessible in medical libraries to clinicians and medical educators. Finally, the references cited here are current, most having appeared within the last five years. Older articles are included for their unique contribution or value as pioneering studies in the field.

The bibliography is organized according to seven topics:

I. *The Cost of Patient Care*—the financial, patient-related and hospital-efficiency costs of medical care (references 1 through 11).

II. *The Problem of Overutilization*—inappropriate and excessive orders for laboratory, radiological, pharmaceutical and surgical services (references 12 through 28).

III. *The Iatrogenic Risks of Patient Care*—general surveys and specific instances of iatrogenic disease but excluding categories such as nosocomial infections and individual drug reactions (references 29 through 36).

IV. *Factors Affecting Laboratory and Ancillary Service Use*—physician knowledge of costs, clin-

ical experience, ability to interpret test results, mode of practice and current reimbursement policies (references 37 through 60).

V. *Decision Analysis and Clinical Decision Making*—the basic principles of decision analysis, including the concepts of the normal value and of the sensitivity, specificity, predictive value and clinical utility of tests (references 61 through 76).

VI. *Clinical Efficacy Studies of Various Tests and Procedures*—applications of laboratory testing, radiography, computerized tomographic scans, ultrasound, electrocardiography and echocardiography services, among others (references 77 through 99).

VII. *Strategies for Changing Physician Ordering Patterns*—interventions such as education, audits, restrictions and administrative maneuvers (references 100 through 119).

Within each of these seven sections, the articles and books have been arranged in alphabetical order by author. Those that apply to more than one section are cross-referenced at the beginning of each section.

I. Costs of Patient Care

Presented here are articles and books that illuminate three issues: (1) historical and current patterns of medical care expenditures, especially in areas controlled by physician decisions, (2) economic theories elucidating both the increasing costs of health care and proposed strategies to reduce cost increases and (3) medical, ethical, economic and political perspectives on the cost problem. They include research reports, conference proceedings, analytic essays and literature reviews. For other related citations, see references 16, 19, 22, 56, 57, 92, 95 and 102.

1. Bloom BS, Kissick PD: *Home and hospital cost of terminal illness. Med Care 1980; 18:560-564*

This retrospective cohort study used billed charges to compare the cost of the last two weeks of life for patients dying in hospital versus dying at home. Death in the hospital was found to cost 10.5 times as much, the higher cost attributable partly to greater use of diagnostic and therapeutic services.

2. Carels EJ, Neuhauser D, Stason WB (Eds): *The Physician and Cost Control. Cambridge, MA, Gunn and Hain, 1980*

The book summarized the proceedings of a

two-day conference held at the Harvard School of Public Health in 1978. Participants concluded that physicians generate a large portion of health care costs by the kinds of tests and services they order. They reviewed evidence on educational strategies to control cost increases and suggested additional means to change physician ordering behavior.

3. Conn RB: *Clinical laboratories—Profit center, production industry or patient-care resource?* *N Engl J Med* 1978; 298:422-427

In this analysis Conn described the underlying economic, educational and technological problems with clinical laboratories and related them to the rising costs of laboratory services. He concluded that while some of these problems may be addressed through regulation, others, such as improving clinical use of laboratory services, require the medical profession's intervention.

4. Enthoven AC: *Shattuck Lecture—Cutting cost without cutting the quality of care.* *N Engl J Med* 1978; 298:1229-1238

Drawing on a number of studies, Enthoven postulated in this essay that much of US medicine today is "flat-of-the-curve medicine," in which application of additional health care resources yields little or no discernible benefit. The current bias is in favor of more care, and more costly care, whether or not it helps the patient. Enthoven argued that curtailment of utilization may cut costs without compromising the quality of care.

5. Fineberg HV: *Clinical chemistries: The high cost of low-cost diagnostic tests*, In Altman SH, Blendon R (Eds): *Medical Technology: The Culprit Behind Health Care Costs?*, DHEW Publication No. (PHS)79-3216. US Dept of Health, Education, and Welfare. Washington, DC, US Government Printing Office, 1979, pp 144-165

In this analysis of laboratory use Fineberg compiled a wide range of published research reports to describe the history and present organization of the laboratory industry and to illuminate the reasons for increased use and cost of laboratory testing. He concluded the analysis by outlining policy objectives in the areas of efficiency, quality and utilization of laboratories.

6. Gibson RM: *National health expenditures, 1979.* *Health Care Financing Review* 1980; 2:1-36

Annually, the Health Care Financing Administration publishes statistics on and analyses of na-

tional health expenditures. The analysis of 1979 data showed that medical care costs totaled \$212 billion in 1979, accounting for 9 percent of the gross national product and more than \$900 per capita. Expenditures for hospital-based care amounted to 40 percent of the health care dollar and cost \$85 billion.

7. Griner PF, Liptzin B: *Use of the laboratory in a teaching hospital—Implications for patient care, education, and hospital costs.* *Ann Intern Med* 1971; 75:157-163

In a descriptive study of laboratory ordering on a medical service it was shown that laboratory tests account for a large and growing proportion of patient bills. At this hospital, costs attributable to laboratory tests increased twice as much as overall hospital costs in five years. Finding evidence that laboratory tests were ordered excessively, the authors described several patterns of overuse.

8. Lee PR, Bradley W, Schroeder SA, et al: *The ailing health care system—Medical Staff Conference, University of California, San Francisco.* *West J Med* 1978 Jun; 128:512-526

The problem of the rising costs of medical care was discussed from the perspectives of a practicing internist, a bioethicist, a hospital administrator and a health policy lawyer. Responding to two clinical cases in this medical grand rounds conference, the four participants reflected on the excessive use of health technology, especially laboratory services, the ethical dilemmas of the cost problem, the prospect of cost controls and policy options for cost containment.

9. Moloney TW, Rogers DE: *Medical technology—A different view of the contentious debate over costs.* *N Engl J Med* 1979; 301:1413-1419

The assumption that large expensive technologies, such as hemodialysis or computerized tomography, contribute substantially to the cost of care was challenged in this essay. Rather, the authors concluded that the growing volume of low-cost services, such as clinical laboratory tests or x-ray studies, accounts for a higher proportion of the burgeoning cost of medical care. Thus, regulatory strategies aimed at the large technologies may not be as effective in controlling costs as changes in physician reimbursement, physician education and hospitals' financial incentives.

10. Myers LP, Schroeder SA: *Physician use of*

services for the hospitalized patient: A review, with implications for cost containment. Milbank Mem Fund Q 1981; 59:481-507

This critical review of research on physician ordering patterns summarized the evidence on cost and excessive use of hospital services, incentives promoting increased ordering and attempts to modify physician behavior. From the empirical data available, the authors concluded that audit of patient cases with feedback to physicians offered the most promise for changing physician behavior.

11. Scitovsky AA: *Changes in the use of ancillary services for "common" illness*. In Altman SH, Blendon R (Eds): *Medical Technology: The Culprit Behind Health Care Costs?*, DHEW Publication No. (PHS)79-3216. US Dept of Health, Education, and Welfare. Washington, DC, US Government Printing Office, 1979, pp 39-56

In a retrospective study Scitovsky assessed the use of ancillary services at one outpatient facility over 20 years. The analysis documented greater than fivefold increases in the use of some procedures for common illnesses. Estimates of national expenditures for laboratory and x-ray services were made on the basis of additional sources of utilization data.

II. The Problem of Overutilization

We selected sources that would provide solid evidence of physician overordering. Although many of the articles focus on laboratory ordering, others illustrate overuse of radiological and surgical procedures, pharmaceuticals and length of stay. For other references, see 4, 7, 8, 10, 30, 81, 88 and 89.

12. Abrams HL: *The "overutilization" of x-rays*. *N Engl J Med* 1979; 300:1213-1216

Three types of overutilization were defined: excessive radiation per film, excessive films per examination and excessive examinations per patient. Factors underlying the latter include physicians' lack of knowledge, undue dependence on x-ray studies, self-imposed need for action and certainty, patient demand, reimbursement policies, institutional requirements, defensive medicine and the practice of radiology by nonradiologists.

13. Bloomgarden Z, Sidel VW: *Evaluation of utilization of laboratory tests in a hospital emergency room*. *Am J Public Health* 1980; 70:525-528

In their retrospective study the authors related

laboratory test utilization to quality of care in a metropolitan teaching hospital emergency room. They considered 32 percent of laboratory test orders unnecessary for clinical decision making and 20 percent not indicated on any grounds. Further, unnecessary tests clustered in only 9 percent of patients, raising the possibility that intervention measures could focus on a handful of patients and physicians.

14. Dixon RH, Laszlo J: *Utilization of clinical chemistry services by medical house staff—An analysis*. *Arch Intern Med* 1974; 134:1064-1067

A case review of house staff utilization of clinical chemistry tests set four criteria of test usefulness: (1) Does the test generate an order for medication or the need for other care? (2) Are test results considered in planning for subsequent patient care? (3) If test results are abnormal, is the test repeated? and (4) If test results are normal, does this rule out a diagnostic consideration? For a cohort of randomly selected medical patients, only 5 percent of laboratory tests yielded a positive answer to one or more of these criteria. The authors concluded that house staff use the chemistry laboratory inefficiently.

15. Eisenberg JM, Williams SV, Garner L, et al: *Computer-based audit to detect and correct overutilization of laboratory tests*. *Med Care* 1977; 15:915-921

This retrospective study, examining multiple determinations of calcium or lactic dehydrogenase (LDH), found that more than half of the determinations were unnecessary. An attempt to educate physicians regarding overuse of LDH determinations failed to affect their use of the test.

16. Griner PF: *Treatment of acute pulmonary edema: Conventional or intensive care?* *Ann Intern Med* 1972; 77:501-506

The experience of adult patients admitted with pulmonary edema was compared before and after the opening of an intensive care unit. Mortality (8 percent) remained unchanged, but duration of hospital stay increased by 2.3 days and hospital bills increased by 46 percent.

17. Hall FM: *Overutilization of radiological examinations*. *Radiology* 1976; 120:443-448

Published research on use of radiologic procedures was analyzed. The major reasons cited for unnecessary use included financial incentives, malpractice considerations, inadequate clinical in-

formation about the patient and inappropriate or controversial indications.

18. Knapp DE, Knapp DA, Speedie MK, et al: *Relationship of inappropriate drug prescribing to increased length of hospital stay. Am J Hosp Pharm* 1979; 36:1334-1337

This study applied criteria for ordering antimicrobial drugs to 77 cases of pyelonephritis, and found that patients who met all criteria for appropriate therapy had significantly shorter hospital stays, averaging two days less. While all of this difference might not have been related to drug prescribing, the results suggest the potential cost savings of more appropriate drug therapy.

19. Luft HS: *How do health-maintenance organizations achieve their "savings"?—Rhetoric and evidence. N Engl J Med* 1978; 298:1336-1343

In a comparison of HMO and fee-for-service costs and utilization Luft found that total costs for HMO enrollees may be 10 percent to 40 percent less, most of this difference attributable to lower hospital admission rates. The data did not support the hypothesis, however, that lower HMO surgical rates were responsible for the difference in hospital admission rates.

20. Maronde RF, Lee PV, McCarron MM, et al: *A study of prescribing patterns. Med Care* 1971; 9:383-395

Reporting a retrospective review of outpatient prescriptions, this paper delineated three types of inappropriate drug prescriptions by physicians and pharmacists: (1) excessive quantities in individual prescriptions, (2) excessively frequent prescriptions for the same drug and (3) inappropriate simultaneous prescriptions for different drugs. Of prescriptions for the most commonly ordered drugs, 13 percent were for excessive quantities of the same drug, most often sedatives and tranquilizers.

21. Martin SP, Donaldson MC, London CD, et al: *Inputs into coronary care during 30 years—A cost effectiveness study. Ann Intern Med* 1974; 81:289-293

A retrospective study of patient care and outcome for patients with myocardial infarctions found that patients recently in hospital received many more laboratory tests and x-ray studies than those admitted 30 years ago. Also increased was the use of electrocardiograms, sedatives and oxygen therapy. Despite the greater inputs to

patient care, no significant changes in length of hospital stays or in-hospital mortality were observed.

22. Parkerson GR Jr: *Cost analysis of laboratory tests in ambulatory primary care. J Fam Pract* 1978; 7:1001-1007

This retrospective analysis considered three factors relating to physician use of laboratory tests: cost to patient, abnormality of results and physician use of results. Laboratory fees made up 32 percent of the total dollars spent on ambulatory office care. Of the portion spent on laboratory blood tests, 20 percent were for tests with normal results, 25 percent for abnormal findings that were followed up by physicians and 55 percent for abnormal results that were not followed up.

23. Pauly MV: *What is unnecessary surgery? Milbank Mem Fund Q* 1979; 57:95-117

An analysis of evidence on excessive use of surgical procedures suggested that the need for a procedure may be defined by considering its benefits and costs. Evidence of unnecessary operations included (1) wide variability among geographic areas and physicians in carrying them out, (2) differences in surgical rates for patients in prepaid programs compared with fee-for-service practices and (3) use of expert opinion to identify cases of unnecessary operations. Because these measures are problematic, Pauly concluded that we cannot at present adequately estimate the amount of unnecessary surgical intervention.

24. Roos NP, Henteleff PD, Roos LL Jr: *A new audit procedure applied to an old question: Is the frequency of T & A justified? Med Care* 1977; 15:1-18

A retrospective study was done of all tonsillectomies and adenoidectomies in one Canadian province during one year. Each patient's case was reviewed to determine the indications for the procedure. Even under the most liberal standards, more than two thirds of the surgical procedures failed to meet standards of good medical practice. On the other hand, under the same criteria, more than 25 percent of the patients presenting appropriate indications for tonsillectomies did not receive them.

25. Schneiderman LJ, DeSalvo L, Baylor S, et al: *The "abnormal" screening laboratory results—Its effect on physician and patient. Arch Intern Med* 1972; 129:88-90

A retrospective review of clinical data showed

that physicians pay little attention to abnormal results of screening procedures. This finding raised questions about the tests' utility and the cost-benefit of routine screening.

26. Schroeder SA, Schlifman A, Piemme TE: *Variation among physicians in use of laboratory tests: Relation to quality of care. Med Care 1974; 12:709-713*

In this study the relative clinical competence of interns caring for patients in a coronary care unit was evaluated by faculty and related to the number of unnecessary tests ordered per intern. The results suggested that physicians' frequency of laboratory test use was not a good measure of quality of care.

27. Vautrain RL, Griner PF: *Physician's orders, use of nursing resources, and subsequent clinical events. J Med Educ 1978; 53:125-128*

This is one of the few reports of research on appropriate physician ordering of nursing services. Physicians at a large teaching hospital were found to order tests of vital signs excessively given the clinical information needed or used. It was suggested that orders for frequent, simple, quick observation or pointed assessment of a patient (such as neurologic checks) often may be more appropriate.

28. Zieve L: *Misinterpretation and abuse of laboratory tests by clinicians. Ann NY Acad Sci 1966; 134:563-572*

In this classic analysis of physician test-ordering behavior, Zieve categorized and described the reasons why clinicians misinterpret laboratory test results or request unnecessary tests. Some of these reasons included (1) overinterpretation of test values, (2) ignorance of extraneous factors that influence tests, (3) unawareness of the nature of the normal distributions, (4) uncritical acceptance of published opinions regarding tests, (5) unnecessary repetition of tests and (6) failure to interpret tests in relation to clinical findings.

III. The Iatrogenic Risks of Patient Care

For this section we compiled recent general reviews of iatrogenic illness among medical and surgical patient populations. The reviews include diagnostic and therapeutic procedure- and drug-related morbidity and mortality. We excluded studies of nosocomial infection, reports of specific complications of individual procedures and ex-

amples of individual drug reactions. For another related reference, see 18.

29. Bush WH Jr, Mullarkey MF, Webb DR: *Adverse reactions to radiographic contrast material. West J Med 1980 Feb; 132:95-98*

This essay summarized the manifestations, possible mechanisms and treatment of the three recognized reactions to radiographic contrast material: (1) a vasomotor effect, (2) an immediate generalized anaphylactoid reaction and (3) a vagal bradycardia.

30. Couch NP, Tilney NL, Rayner AA, et al: *The high cost of low-frequency events—The anatomy and economics of surgical mishaps. N Engl J Med 1981; 304:634-637*

In a one-year prospective study 36 of 5,612 surgical patients (0.6 percent) suffered surgical mishaps, 20 of which ultimately proved fatal. In nearly two thirds of the cases, the iatrogenic disease was judged to be due to an unnecessary, improperly conducted or inappropriate operative procedure. The authors found five sources of physician error: (1) overestimation of surgical skills, (2) unwarranted urgency in performing major surgical procedures, (3) urge for perfection beyond the patient's needs, (4) uncritical performance of vogue therapies and (5) insufficient restraint and deliberation in patient care.

31. D'Arcy PF, Griffin JP: *Iatrogenic Diseases, 2nd Ed. New York, Oxford University Press, 1979*

In this review of untoward patient reactions to therapeutic agents, including adverse drug-drug and drug-patient interactions, the authors repeatedly emphasized the need for minimizing the number of drugs and for avoiding polypharmacy in therapy. It included a comprehensive summary of the epidemiology of drug-related iatrogenic illness.

32. Porter J, Jick H: *Drug-related deaths among medical inpatients. JAMA 1977; 237:879-881*

Monitoring of patients admitted to acute disease wards in seven countries between 1971 and 1976 showed an incidence of 0.9 per 1,000 drug-related deaths. The authors considered preventable the deaths due to excessive intravenous fluid therapy and potassium chloride therapy.

33. Schimmel EM: *The hazards of hospitalization. Ann Intern Med 1964; 60:100-110*

In this early prospective study the author ex-

amined the type and frequency of complications occurring in patients hospitalized on the medical service of a large teaching hospital. During eight months, 20 percent of patients had adverse reactions, including 48 life-threatening episodes and 16 deaths. Drug reactions, transfusion reactions, complications of diagnostic and therapeutic procedures, and acquired infections accounted for most of the total.

34. Schroeder SA, Marton KI, Strom BL: *Frequency and morbidity of invasive procedures—Report of a pilot study from two teaching hospitals. Arch Intern Med 1978; 138:1809-1811*

The frequency of and complications from invasive procedures at two teaching hospitals were assessed in the pilot study. It found that during the six-week study period 231 procedures were carried out on 303 medical patients, and 29 complications occurred in 20 cases. While no permanent damage or deaths were observed, more than three quarters of the complications required specific therapy or prolonged hospital stays, or both. The authors pointed out the need for systematic surveillance of such procedures.

35. Steel K, Gertman PM, Crescenzi C, et al: *Iatrogenic illness on a general medical service at a university hospital. N Engl J Med 1981; 304: 638-642*

A retrospective review documented that 36 percent of 815 consecutive general medical patients at a university teaching hospital had an iatrogenic illness while in hospital. For a fourth of those patients, the iatrogenic illness was either life-threatening or disabling; it appeared to contribute to the deaths of 6 percent. Factors associated with iatrogenic events included patient age, number of drugs received, length of stay, condition on admission, and intensive care unit or coronary care unit admission.

36. Trunet P, Le Gall JR, Lhoste F, et al: *The role of iatrogenic disease in admissions to intensive care. JAMA 1980; 244:2617-2620*

In this prospective study, 12 percent of 325 patients admitted to a multidisciplinary intensive care unit during one year were admitted to hospital due to iatrogenic illness. They included eight fatalities and 13 life-threatening complications.

IV. Factors Affecting Laboratory and Ancillary Service Use

Numerous factors affect physician ordering.

The following references identify, illustrate and evaluate factors that encourage or discourage test ordering. Some of these factors include physician training, age, understanding of clinical indications, patient load, hospital setting, knowledge of costs, financial return and patient demand. For other relevant articles, see 5, 10, 17, 93, 114 and 115.

37. Abbott JA, Tedeschi MA, Cheitlin MD: *Graded treadmill stress testing—Patterns of physician use and abuse. West J Med 1977 Mar; 126: 173-178*

In a prospective study the authors assessed physician use and understanding of the graded treadmill stress test. Although physicians complied with the predetermined ordering criteria for graded treadmill stress tests, they often relied excessively on the test results, behaving as if the results were diagnostically definitive.

38. Bailey RM: *Clinical Laboratories and the Practice of Medicine—An Economic Perspective. Berkeley, California, McCutchan Publishing Corporation, 1979*

The economic and political factors underlying the increasing use and abuse of laboratory services are examined in this book. Such factors include physician ordering practices, organization of the laboratory industry, medical insurance, and governmental policies.

39. Casscells W, Schoenberger A, Graboyes TB: *Interpretation by physicians of clinical laboratory results. N Engl J Med 1978; 299:999-1001*

The authors summarized survey evidence of physician comprehension of probabilistic reasoning. Greater than 80 percent demonstrated a misunderstanding of such reasoning, many exhibiting an unquestioning belief in laboratory test results. This combination of misconception and overzealous faith in laboratory diagnosis may lead to overuse of the clinical laboratory.

40. Childs AW, Hunter ED: *Non-medical factors influencing use of diagnostic x-ray by physicians. Med Care 1972; 10:323-335*

A retrospective study of x-ray services provided to aged patients compared patterns of x-ray use by physicians. More diagnostic x-ray films were used by physicians providing x-ray studies directly to patients, by younger physicians and by specialists. The authors pointed out the financial incen-

tive for physicians owning radiologic equipment to use it more heavily.

41. Connelly D, Steele B: *Laboratory utilization—Problems and solutions. Arch Pathol Lab Med* 1980; 104:59-62

The evidence for inappropriate utilization of laboratory services was summarized and the factors contributing to overuse listed. Suggestions for improving physician ordering, based on research to date, were offered.

42. Daniels M, Schroeder SA: *Variations among physicians in use of laboratory tests—II. Relation to clinical productivity and outcomes of care. Med Care* 1977; 15:482-487

This study correlated variations in the use of laboratory tests with physician total patient load, productivity and blood pressure control for a cohort of ambulatory hypertensive patients. Large (up to 20-fold) variations in laboratory utilization existed among similarly trained physicians practicing in a university medical clinic. Increased use of tests did not correlate with better patient outcome of care or increased physician productivity.

43. Dans PE: *The great zebra hunt—A view of internal medicine from the walk-in clinic. The Pharos*, 1978 Jul, pp 2-6

The author of this essay entreated physicians, "If you hear hoofbeats in the distance, call it a horse before you call it a zebra." It was stressed that undue emphasis on diagnostic testing may turn the virtue of thoroughness into a fault and result in repeated, costly and futile searches for rare diagnoses.

44. Dresnick SJ, Roth WI, Linn BS, et al: *The physician's role in the cost-containment problem. JAMA* 1979; 241:1606-1609

A survey of faculty, interns and medical students showed that all three groups were unfamiliar with the costs of frequently ordered hospital services. In general, those surveyed tended to underestimate costs, perhaps contributing to overordering of hospital services.

45. Eisenberg JM: *Sociologic influences on decision-making by clinicians. Ann Intern Med* 1979; 90:957-964

The research on sociologic factors that may affect clinical decision making was reviewed. Four factors were investigated and illustrated: patient

characteristics, physician characteristics, the doctor-patient relationship, and the professional role of the physician.

46. Freeborn DK, Baer D, Greenlick MR, et al: *Determinants of medical care utilization: Physicians' use of laboratory services. Am J Public Health* 1972; 62:846-853

The authors analyzed laboratory utilization by physicians at the Portland Kaiser-Permanente HMO. Physicians varied substantially in laboratory use, with internists ordering the most. Factors linked to physician variability in ordering included medical school training, age, board certification, and length of time at the HMO.

47. Greenland P, Mushlin AI, Griner PF: *Discrepancies between knowledge and use of diagnostic studies in asymptomatic patients. J Med Educ* 1979; 54:863-869

This paper summarized a survey of residents, faculty and practicing physicians at a large teaching hospital regarding their ordering practices and knowledge of diagnostic tests. Although reliance on routine screening procedures of asymptomatic patients declined with each succeeding year of residency, physicians' knowledge of individual diagnostic procedures appeared to be unrelated to their use of these services.

48. Hardison JE: *To be complete. N Engl J Med* 1979; 300:193-194

Hardison listed the most common, easily recognized defenses given by physicians for ordering or performing unnecessary tests and procedures. He emphasized that the less a test is indicated, the more likely a positive result will be falsely positive.

49. Kelly SP: *Physicians' knowledge of hospital costs. J Fam Pract* 1978; 6:171-172

A survey in a community hospital found that staff physicians were able to identify correctly the prices of less than half of 20 commonly ordered hospital services. Knowledge of prices was unrelated to specialty, training or hospital hours.

50. Koran LM: *The reliability of clinical methods, data and judgments. N Engl J Med* 1975; 293: 642-646 (part 1), 695-701 (part 2)

Published research on the reliability of physician observations and clinical judgments was reviewed. Great variability and frequent disagreements among physicians (unreliability) regarding

clinical evidence were documented and evaluated in the areas of physical examination and the interpretation of x-ray studies.

51. Nagurney JT, Braham RL, Reader GG: *Physician awareness of economic factors in clinical decision-making. Med Care* 1979; 17:727-736

This survey of residents and attending physicians at a university hospital found that, with the exception of daily room rates, physicians had little knowledge of the prices of common hospital services. They also reportedly understood little of third party health insurance plans or benefits.

52. Pineault R: *The effect of medical training factors on physician utilization behavior. Med Care* 1977; 15:51-67

Pineault investigated the relationship between physician ordering of medical resources and physician training and specialty. He concluded that physicians with a scientific training and orientation used fewer services in general than other physicians. Ordering, however, also was linked to conditions of clinical uncertainty: when ambiguity was high, physicians ordered more services.

53. Relman AS: *The new medical-industrial complex. N Engl J Med* 1980, 303:963-970

In this analysis of the new "medical-industrial complex," Relman explained the incentives for physicians and hospitals to (1) overuse services, especially technological services, (2) fragment service provision and (3) "cream" patients. These factors place physicians, as patient representatives, in a crucial position. He encouraged physicians to put their patients' needs first and to eschew conflicting financial ties.

54. Roos NP, Roos LL Jr, Henteleff PD: *Elective surgical rates—Do high rates mean lower standards? Tonsillectomy and adenoidectomy in Manitoba. N Engl J Med* 1977; 297:360-365

A retrospective study examined reasons for regional variations in surgical procedure rates. No substantiated explanations were found other than individual physician practice loads and patterns. Physician age, training and specialty were poorly correlated with frequency of surgical procedures or standards of carrying out operations.

55. Russe HP: *The use and abuse of laboratory tests. Med Clin N Am* 1969; 53:223-231

This discussion of laboratory testing covered four topics: the use and utility of "routine"

screening tests, the cost of medical care as related to laboratory testing, the factors affecting use of test results and the abuse of laboratory testing. The author concluded that physicians must be well-informed and have up-to-date knowledge of technological advances in order to use the laboratory effectively and efficiently.

56. Schroeder SA, O'Leary DS: *Differences in laboratory use and length of stay between university and community hospitals. J Med Educ* 1977; 52:418-420

Research contrasted length of hospital stay and use of diagnostic services for patients admitted to a teaching and a nonteaching community hospital. Although the same internists admitted patients to both hospitals, patients at the teaching hospital received significantly more diagnostic services. Greater frequency of laboratory testing at the teaching hospital accounted for 56 percent of the difference in charges between the two hospitals.

57. Schroeder SA, Showstack JA: *Financial incentives to perform medical procedures and laboratory tests: Illustrative models of office practice. Med Care* 1978; 16:289-298

This report analyzed financial return as a factor affecting physician ordering behavior. The authors concluded that internists in private practice can double or triple their incomes by conducting more office laboratory procedures. Further, reimbursement rates for these procedures are much higher than those for physician time in direct patient care, thus encouraging the use of laboratory testing.

58. Stolley PD, Becker MH, Lasagna L, et al: *The relationship between physician characteristics and prescribing appropriateness. Med Care* 1972; 10:17-28

Correlating survey results from physicians and experts, this study characterized physicians who were judged to be appropriate prescribers. More appropriate prescribers were younger, more recent graduates, better educated and, further, they had larger practices, sought fewer consultations and spent less time with their patients. Finally, they tended to seek prescribing information from medical journals or retail pharmacies.

59. Tancredi LR, Barondess JA: *The problem of defensive medicine. Science* 1978; 200:879-882

Reviewing studies about defensive medicine, the authors found very little valid and reliable in-

formation on the use of diagnostic testing and other clinical measures to avoid malpractice litigation. Nevertheless, they concluded that the practice of defensive medicine does not contribute substantially to the increasing cost of care and is less widespread than originally supposed.

60. Wertman BG, Sostrin SV, Pavlova Z, et al: *Why do physicians order laboratory tests? A study of laboratory test request and use patterns. JAMA* 1980; 243:2080-2082

A survey of physicians showed that diagnosis, screening and monitoring were the most frequent reasons given by physicians for their ordering; also frequently cited was a previously abnormal result. Fears of malpractice, educational purposes and unavailability of previous results were far less commonly cited as contributing factors.

V. Decision Analysis and Clinical Decision Making

An understanding of the basic principles of decision analysis is essential for the proper selection and interpretation of diagnostic tests and procedures. The articles selected here provide a clinician with basic knowledge of these concepts, such as test sensitivity, specificity and predictive value, as well as examples of their concrete clinical application. Also included are several papers reviewing the limitations of decision analysis in the clinical setting.

61. Feinstein AR: *Clinical biostatistics—The haze of Bayes, the aerial palaces of decision analysis, and the computerized Ouija board. Clin Pharmacol Ther* 1977; 21:482-496

The author considered the mechanisms, merits, difficulties and flaws of a predominantly mathematical approach to clinical decision making. He argued that clinicians can make effective decisions and perform useful cost-benefit analyses by specifying and using the pragmatic strategies good clinicians have always employed, not by creating potentially misleading quantifications.

62. Galen RS, Gambino SR: *Beyond Normality—The Predictive Value and Efficiency of Medical Diagnoses. New York, John Wiley & Sons, 1975*

This book was designed to enhance clinicians' understanding of the concepts of the normal and abnormal value. It reviewed the concept of predictive value, described the statistical methods for its determination and provided many examples

of its application to problems taken from medical journals.

63. Gorry GA, Pauker SG, Schwartz WB: *The diagnostic importance of the normal finding. N Engl J Med* 1978; 298:486-489

Clinicians generally use normal results from diagnostic tests only to rule out specific diseases. However, this article showed that normal values may be used to distinguish between diagnoses that are associated with normal results with different frequencies. The authors proposed a method of applying Bayes' rule that permits this use of normal values.

64. Griner PF, Mayewski RJ, Mushlin AI, et al: *Selection and interpretation of diagnostic tests and procedures: Principles and applications. Ann Intern Med* 1981; 94 (Part 2):553-600

The authors reviewed the proper selection and interpretation of diagnostic tests and procedures, including discussion of operating characteristics such as test sensitivity and specificity, predictive value of various test results and sample application to common clinical problems such as iron deficiency anemia, systemic lupus erythematosus, cholelithiasis, pulmonary embolism, syphilis and bronchogenic carcinoma.

65. Krieg AF, Gambino R, Galen RS: *Why are clinical laboratory tests performed? When are they valid? JAMA* 1975; 233:76-78

A brief discussion of the value and inherent statistical limitations of diagnostic tests was given. It was concluded that the usefulness of a positive test result varies not only with the sensitivity and specificity of the test but also with the incidence of the disease in the population tested.

66. McNeil BJ, Keeler E, Adelstein SJ: *Primer on certain elements of medical decision making. N Engl J Med* 1975; 293:211-215

This primer described three methods for critical evaluation of diagnostic procedures—the decision matrix, the receiver operating characteristic (ROC) curve and information theory. These methods consider the ability of a diagnostic test to find patients with disease while simultaneously excluding patients without disease. They also can take into account the underlying purpose of a physician ordering the test (screening for disease, diagnostic information or cost-benefit calculation).

67. Pauker SG: *Coronary artery surgery: The use*

of decision analysis. *Ann Intern Med* 1976; 85: 8-18

In this analysis Pauker demonstrated the application of decision analysis methodology to the problem of choosing between medical and surgical therapy in patients with coronary artery disease. The analysis entailed consideration of patient preference, disease severity, expected prognosis with medical therapy, surgical mortality rate, graft patency rate, and expected symptomatic and mortality responses to surgical therapy. The author found coronary bypass procedures to be preferable for patients with disabling angina but not for asymptomatic patients.

68. Pauker SG, Kassirer JP: *Therapeutic decision making: A cost-benefit analysis*. *N Engl J Med* 1975; 293:229-234

The authors applied decision analysis to the dilemma of whether or not to treat a patient having an uncertain diagnosis by developing a method for calculating a "therapeutic threshold." If the probability of the disease in a certain patient was greater than this threshold, treatment was advisable; if the probability was below the threshold, treatment was to be withheld.

69. Pauker SG, Kassirer JP: *The threshold approach to clinical decision making*. *N Engl J Med* 1980; 302:1109-1117

This analysis drew on the concepts of decision theory to develop two types of threshold probabilities. These can be used by physicians in deciding whether to treat immediately, to obtain more information by performing a test, or to withhold treatment. Two examples of applications were presented.

70. Potsaid MS: *Diagnostic imaging in perspective*. *JAMA* 1980; 243:2412-2417

The author of this essay proposed that the conventional four-box decision matrix (true positive, true negative, false positive and false negative) be modified for image interpretations to a six-box matrix that would include equivocal or indeterminate results. Calculation of equivocally positive and equivocally negative rates, plus consideration of both benefits and costs of diagnostic imaging examinations, would aid physician decision making and improve patient care.

71. Ransohoff DF, Feinstein AR: *Is decision analysis useful in clinical medicine?* *Yale J Biol Med* 1976; 49:165-168

This essay presented several caveats regarding the application of decision analysis to clinical situations. Difficulties of application arise in (1) including all important courses of events, (2) attaching quantitative assessments to the probabilities of each outcome, (3) assigning utility values to each outcome and (4) deciding who does the assessments. Because of these difficulties, clinicians will probably continue to rely primarily on intuition, common sense and clinical judgment. However, when applied, decision analysis may help clinicians to understand and dissect the elements of such clinical judgment.

72. Schwartz WB: *Decision analysis—A look at the chief complaints*. *N Engl J Med* 1979; 300: 556-559

In this article Schwartz lamented the poor acceptance of decision analysis by practicing physicians and discussed the most frequent complaints about decision analysis. Even after refuting the common objections, he concluded that acceptance will be slow in coming.

73. Schwartz WB, Gorry GA, Kassirer JP, et al: *Decision analysis and clinical judgment*. *Am J Med* 1973; 55:459-472

This case study illustrated the application and utility of decision analysis for management of patients with severe hypertension and possible renal artery stenosis. The possible courses of action available to the clinician in a complex clinical situation were evaluated both qualitatively and quantitatively.

74. Sisson JC, Schoomaker EB, Ross JC: *Clinical decision analysis—The hazard of using additional data*. *JAMA* 1976; 236:1259-1263

The authors postulated in this article that the hazards of obtaining more information extend beyond the monetary costs and risks to physical well-being and often are unrecognized by physicians. New clinical information may lead to a course of action that does more harm than good to patients. Decision analysis may help solve this dilemma.

75. Tversky A, Kahneman D: *Judgment under uncertainty: Heuristics and biases*. *Science* 1974; 185:1124-1131

This classic essay on decision analysis showed that clinicians' beliefs concerning the likelihood of uncertain events may be determined by reliance on a number of heuristic principles. In general,

although such unproved or unprovable principles are valuable for empirical trials, they sometimes may lead to severe, systematic errors in judgment. Three examples of such heuristics were presented.

76. Vecchio TJ: *Predictive value of a single diagnostic test in unselected populations. N Engl J Med* 1966; 274:1171-1173

In a pioneering application of Bayes' theorem to diagnostic tests, the author described a technique for estimating the predictive value of a test result when the sensitivity and specificity of the test and the prevalence of the disease in the population are known.

VI. Clinical Efficacy Studies

Summarized are examples of recent studies of the costs and benefits of various diagnostic tests and procedures, including several concrete applications of the principles of decision analysis to common or difficult clinical situations. These studies illustrate how clinical research may treat the issue of cost-effective medical care in specific and practical fashion.

77. Barkin J, Vining D, Miale A Jr, et al: *Computerized tomography, diagnostic ultrasound, and radionuclide scanning—Comparison of efficacy in diagnosis of pancreatic carcinoma. JAMA* 1977; 238:2040-2042

These three procedures were compared according to the sensitivity, specificity and cost per procedure, and a logical approach to evaluating patients with suspected pancreatic carcinoma was proposed.

78. Bartha GW, Nugent CA: *Routine chest roentgenograms and electrocardiograms—Usefulness in the hypertensive workup. Arch Intern Med* 1978; 138:1211-1213

A total of 116 hypertensive patients referred to a hypertension clinic had routine x-ray studies of the chest or electrocardiograms, or both. Retrospective review of these cases showed that these procedures led to therapeutic or diagnostic interventions in only two instances, were not useful as baseline examinations or for prognostic purposes and did not influence hypertensive management.

79. Bell RS, Loop JW: *The utility and futility of radiographic skull examination for trauma. N Engl J Med* 1971; 284:236-239

This classic paper reported a prospective investigation of the information yield of skull films

taken for injury. The authors developed a decision strategy for selecting for radiographic study those patients with a definite likelihood of fracture. They calculated that use of this strategy would save \$15 million per year (in 1971 dollars) if applied nationally.

80. Bunker JP, Barnes BA, Mosteller F (Eds): *Costs, Risks, and Benefits of Surgery. New York, Oxford University Press, 1977*

The application of cost-benefit calculations and decision analysis to a variety of surgical procedures was shown, including duodenal ulcer surgical therapy, inguinal herniorrhaphy, cholecystectomy for silent gallstone and elective hysterectomy.

81. Edwards LD, Levin S, Balagtas R, et al: *Ordering patterns and utilization of bacteriologic culture reports. Arch Intern Med* 1973; 132:678-682

Examination of physician ordering of bacteriological cultures at an urban teaching hospital showed the lack of a consistent or logical approach to their use. Cultures were frequently obtained from patients already receiving antibiotic treatment, were rarely accompanied by immediate Gram stains and seldom resulted in a change in therapy.

82. Eisenberg JM, Goldfarb S: *Clinical usefulness of measuring prothrombin time as a routine admission test. Clin Chem* 1976; 22:1644-1647

Determination of the prothrombin time is a useful measure of hepatic synthetic function in liver disease and of coagulation in bleeding. This study showed, however, that its measurement as a routine screening test to detect occult liver disease or coagulopathy has no advantage over a careful history and physical examination.

83. Eisenberg JM, Rose JD, Weinstein AJ: *Routine blood cultures from febrile outpatients—Use in detecting bacteremia. JAMA* 1976; 236:2863-2865

A prospective study provided evidence that blood cultures are of little diagnostic or therapeutic utility in febrile adult outpatients.

84. Fineberg HV, Bauman R, Sosman M: *Computerized cranial tomography—Effect on diagnostic and therapeutic plans. JAMA* 1977; 238:224-227

The results of cranial computerized tomogra-

phy, examined prospectively on 194 consecutively scanned patients at a university teaching hospital, had substantial effects both on the need for other neurodiagnostic procedures and upon therapy.

85. Griner PF, Oranburg PR: Predictive values of erythrocyte indices for tests of iron, folic acid and vitamin B₁₂ deficiency. *Am J Clin Pathol* 1978; 70:748-752

This application of basic principles of decision analysis showed that erythrocyte indices are sufficiently predictive for or against deficiency states to guide more appropriate further diagnostic testing.

86. Jacobson KW, Branch LB, Nelson HS: Laboratory tests in chronic urticaria. *JAMA* 1980; 243:1644-1646

The outcome of extensive diagnostic testing of patients with chronic urticaria was outlined to indicate that, with the possible exception of sinus x-ray films, laboratory studies are unlikely to be helpful unless suggested by historical or clinical findings.

87. Larson EB, Omenn GS, Loop JW: Computed tomography in patients with cerebrovascular disease: Impact of a new technology on patient care. *Am J Roentgenol* 1978; 131:35-40

A retrospective cohort analysis following addition of computerized tomographic (CT) scanning to the diagnostic testing of patients with suspected cerebrovascular disease found no changes in length of hospital stay, speed of diagnostic evaluation, nature of treatment or discharge plans. Use of lumbar punctures and radionuclide brain scans declined, but aggregate charges for all diagnostic procedures increased after introduction of the CT scans. In this patient population, CT scans may raise costs without demonstrably improving patient care.

88. MacEwan DW, Kavanagh S, Chow P, et al: Manitoba barium enema efficacy study. *Radiology* 1978; 126:39-44

Among 16,594 barium enema studies reviewed in a survey in Manitoba, 1,000 significant abnormalities were discovered. Referring physicians were found to be very accurate in predicting the likelihood of these abnormalities. The investigators estimated that 30 percent of the adult studies were unnecessary, and argued that a 10 percent reduction in use of barium enemas could be ac-

complished by the referring physicians without compromising quality of care.

89. Marton KI, Sox HC Jr, Wasson J, et al: The clinical value of the upper gastrointestinal tract roentgenogram series. *Arch Intern Med* 1980; 140:191-195

A prospective study of the use of an upper gastrointestinal (UGI) series in 4,983 outpatients with various abdominal complaints concluded that the UGI series (1) gave significantly abnormal results in approximately 20 percent of cases, (2) rarely led to changes in treatment and (3) was ordered inappropriately in approximately 30 percent of cases. Four historical attributes identified 95 percent of symptomatic patients with abnormal UGI findings: (1) previous history of peptic ulcer disease, (2) age greater than 50, (3) relief of abdominal pain with food or milk and (4) abdominal pain occurring within one hour of eating.

90. McNeil BJ, Adelstein SJ: Measures of clinical efficacy—The value of case finding in hypertensive renovascular disease. *N Engl J Med* 1975; 293:221-226

91. McNeil BJ, Varady PD, Burrows BA, et al: Measures of clinical efficacy—Cost-effectiveness calculations in the diagnosis and treatment of hypertensive renovascular disease. *N Engl J Med* 1975; 293:216-221

These two papers addressed the clinical efficacy and cost-effectiveness of the diagnosis and therapy of renovascular disease. In the first paper the authors concluded that blind medical antihypertensive therapy in even moderately compliant patients may be more beneficial than the identification and surgical treatment of renovascular hypertension. In the second they estimated that \$10 to \$13 billion would be spent to screen and treat the total US population for renovascular hypertension.

92. McNeil BJ, Adelstein SJ: Determining the value of diagnostic and screening tests. *J Nucl Med* 1976; 17:439-448

Applying the basics of decision analysis, the authors evaluated the utility of commonly used diagnostic procedures including the radioactive iodine uptake scan, the lung scan, the serum folate level, pelvimetry, mammography, the serum digoxin radiometric assay, the brain scan and the

radiologic evaluation of renovascular hypertension.

93. McNeil BJ, Pauker SG: *The patient's role in assessing the value of diagnostic tests. Radiology 1979; 132:605-610*

The authors described the role that patient attitudes play in the evaluation of new diagnostic tests. Consideration of patient attitudes toward potential risks and morbidity of various procedures may lead a clinician to act in a diametrically opposite direction to that stemming from traditional life-expectancy calculations alone.

94. Mintz GS, Kitler MN: *Clinical value and limitations of echocardiography—Its use in the study of patients with infectious endocarditis. Arch Intern Med 1980; 140:1022-1027*

The authors reviewed the state of the art of echocardiography in the diagnosis of infective endocarditis. Contrasting M-mode echocardiography with two-dimensional echocardiography, they concluded that, with the low sensitivity of the techniques, a negative echocardiographic study does not exclude the diagnosis of endocarditis. Furthermore, until specificity is better defined the prognostic implications of a positive study for valve replacement or embolization remain controversial.

95. Neuhauser D, Lewicki AM: *What do we gain from the sixth stool guaiac? N Engl J Med 1975; 293:226-228*

The authors argued that multiple sequential screening tests, even relatively inexpensive tests such as the stool guaiac, can be costly in terms of cases detected, and increasingly so for each additional test done. The marginal cost per case detected depends on the prevalence of the disease in the population screened as well as the sensitivity of the screening test.

96. Rubenstein LZ, Greenfield S: *The baseline ECG in the evaluation of acute cardiac complaints. JAMA 1980; 244:2536-2539*

This retrospective study examined the utility of obtaining baseline electrocardiograms in asymptomatic persons. Of 236 patients without previous heart disease presenting to two emergency rooms with chest pain, only a small proportion (4.7 percent) would have benefited from having a baseline electrocardiogram available, either by avoiding an unnecessary hospital admission or an inappropriate discharge home.

97. Safran C, Desjorges JF, Tschlis PN, et al: *Decision analysis to evaluate lymphangiography in the management of patients with Hodgkin's disease. N Engl J Med 1977; 296:1088-1092*

Analyzing several hypothetical cases, the authors applied decision analysis to the clinical problem of staging Hodgkin's disease to determine the population for whom lymphangiography was appropriate. For asymptomatic patients, they concluded that lymphangiography was most useful for patients with either a relatively low or very high prior probability of Stage IV disease.

98. Sagel SS, Evens RG, Forrest JV, et al: *Efficacy of routine screening and lateral chest radiographs in a hospital-based population. N Engl J Med 1974; 291:1001-1004*

This prospective cost-benefit analysis of more than 10,000 x-ray studies of the chest concluded that (1) routine screening admission or preoperative chest x-ray studies were not warranted in patients younger than 20, (2) routine lateral chest x-ray films were not warranted in patients aged 29 to 39 unless chest disease was suspected and (3) routine lateral chest x-ray studies were warranted in patients older than age 40 years.

99. Wortzman G, Holgate RC, Morgan PP: *Cranial computed tomography: An evaluation of cost effectiveness. Radiology 1975; 117:75-77*

According to this retrospective analysis, cranial computerized tomographic (CT) scans obviate the need for pneumoencephalography and angiography. Moreover, the resulting declines in average length of patient hospital stay and in the number of neurology admissions suggest that if used appropriately a single CT scanner could save up to \$2 million a year.

VII. Strategies for Changing Physician Ordering Behavior

Selected here are overviews of strategies and experimental trials of interventions that have been proposed specifically to change physician test ordering behavior. These include educational programs, cost-auditing, restrictions and rationing, barriers, positive incentives, risk-sharing and administrative maneuvers. Excluded are more general proposals to address the dilemma of rising health care costs such as competition or reimbursement reform. For other related references, see 9, 10 and 15.

100. Dyck FJ, Murphy FA, Murphy JK, et al:

Effect of surveillance on the number of hysterectomies in the province of Saskatchewan. N Engl J Med 1977; 296:1326-1328

After the number of hysterectomies increased by 72 percent over seven years, a list of indications and criteria for hysterectomies was promulgated and audits of hysterectomies undertaken. After this intervention, the proportion of "unjustified" hysterectomies declined from 23 percent to less than 10 percent. The total number of hysterectomies dropped by nearly 33 percent over the subsequent four-year period.

101. Eisenberg JM: *An educational program to modify laboratory use by house staff. J Med Educ 1977; 52:578-581*

In this report of an experimental trial, house staff had a significant, but temporary, benefit from an educational program in reducing use of routine admission prothrombin time determinations. This result emphasized the need to measure long-term outcomes from educational programs and to institute repetitive or follow-up educational maneuvers to ensure lasting effects.

102. Eisenberg JM, Rosoff AJ: *Physician responsibility for the cost of unnecessary medical services. N Engl J Med 1978; 299:76-80*

According to this essay, although most diagnostic and therapeutic services are ordered by physicians, physicians with fee-for-service practices have little incentive to contain medical costs. As a way of controlling costs, the authors proposed having the physician, hospital, insurer and patient all share in paying for medical services that a peer-review group finds unnecessary.

103. Gray G, Marion R: *Utilization of a hematology laboratory in a teaching hospital. Am J Clin Pathol 1973; 59:877-882*

This early example of the "barrier" method of controlling laboratory utilization showed that use of coagulation studies could be limited. Despite increases in the overall hospital and average per patient clinical laboratory workload, use of several coagulation tests declined after the laboratory removed the tests from the routine requisition forms and required that the hematology resident be consulted before the tests were ordered.

104. Griner PF, Medical House Staff, Strong Memorial Hospital: *Use of laboratory tests in a teaching hospital: Long-term trends—Reductions*

in use and relative cost. Ann Intern Med 1979; 90:243-248

The authors of this descriptive study reported that at a large university hospital the number of chemistry tests ordered declined significantly and the number of microbiology, hematology or radiology tests ordered per patient ceased to increase between 1970 and 1977. Possible explanations for this decline in growth included increased reliance on test batteries instead of individual tests and reduced use of non-automated tests. Also credited was a long-term administrative and educational effort aimed at improving laboratory use by physicians.

105. Hudson JI, Braslow JB: *Cost containment education efforts in United States medical schools. J Med Educ 1979; 54:835-840*

According to this report, a third of 119 US medical schools surveyed by the Association of American Medical Colleges in 1978 were undertaking some form of education in cost containment for undergraduate medical students or residents or both.

106. Johns RJ, Blum BI: *The use of clinical information systems to control cost as well as to improve care. Trans Am Clin Climatol Assoc 1979; 90:140-152*

This essay argued that use of five interlocking clinical information systems (a clinical laboratory system, radiology reporting system, unit dose drug distribution system, minirecord system and ward information management system) can provide relevant clinical information at the time and place of decisions. Physicians can thus be encouraged to use hospital resources prudently.

107. Karas S Jr: *Cost containment in emergency medicine. JAMA 1980; 243:1356-1359*

A study identified the 100 most expensive laboratory tests, roentgenograms, medications and supplies in a community hospital emergency room. A subsequent educational program emphasizing cost containment led to a 10 percent reduction in laboratory and radiology charges.

108. Lawrence RS: *The role of physician education in cost containment. J Med Educ 1979; 54:841-847*

The author reviewed several intervention strategies for making physicians more aware of the financial implications of their clinical deci-

sions. These strategies included cost auditing, educational programs and test rationing.

109. Lyle CB Jr, Bianchi RF, Harris JH, et al: *Teaching cost containment to house officers at Charlotte Memorial Hospital. J Med Educ* 1979; 54:856-862

This paper reported the impact of a house staff cost containment program utilizing individualized review of monthly total hospital costs, supplemented by review of itemized bills and audit of ordering habits over 3½ years. This program resulted in a 21 percent reduction in length of stay and a rise in total cost per admission of 4.3 percent per year versus 14.5 percent per year on other services.

110. Martin AR, Wolf MA, Thibodeau LA, et al: *A trial of two strategies to modify the test-ordering behavior of medical residents. N Engl J Med* 1980; 303:1330-1336

The effects of faculty auditing of medical records and of positive financial incentives on limiting test ordering by medical residents was reported in this paper. All residents, including a control group, significantly reduced laboratory testing during the intervention period. Chart auditing produced dramatic (47 percent) and sustained reductions; financial incentives yielded no benefit over controls.

111. Mitchell JH, Hardacre JM, Wenzel FJ, et al: *Cholecystectomy peer review: Measurement of four variables. Med Care* 1975; 13:409-416

Process and outcome analyses of patients undergoing routine cholecystectomy showed that surgeons differed significantly in their patients' length of postoperative stay. When this result was presented to the surgeons, those who had kept their patients in the hospital the longest reduced their patients' stay by an average of nearly one day.

112. Nelson RB: *Teaching technologic restraint—An evaluation of a single session. Evaluation and the Health Professions* 1978; 1:21-28

A significant, but transient, decline in ordering of serum determinations of vitamin B₁₂ and folate levels followed a grand rounds educational session on their limitations in the diagnosis of anemia. This research report underscored the necessity for constant reinforcement and emphasis if voluntary restraint of health care costs by physicians is to be successful.

113. Rhyne RL, Gehlbach SH: *Effects of an educational feedback strategy on physician utilization of thyroid function panels. J Fam Pract* 1979; 8:1003-1007

According to this research report, an educational feedback strategy significantly reduced the rate of ordering of thyroid function tests for three months following the intervention. Ordering returned to the preintervention level within six months, however. The authors concluded that other more powerful factors must compete with rational decision making in test ordering by physicians.

114. Robertson WO: *Costs of diagnostic tests: Estimates by health professionals. Med Care* 1980; 18:556-559

This survey of 97 physicians, medical students and nurses found that they were able to estimate the approximate charges for ten common diagnostic tests in only 30 percent to 42 percent of cases. No improvement was noted one year after distribution of charge schedules and copies of individual patients' bills.

115. Schroeder SA, Kenders K, Cooper JK, et al: *Use of laboratory tests and pharmaceuticals—Variation among physicians and effect of cost audit on subsequent use. JAMA* 1973; 225:969-973

In this study 33 faculty internists at a university medical center were found to have up to 17-fold differences in costs of laboratory tests ordered for similar patients. Distribution of the results of a cost-audit resulted in a 29 percent decline in laboratory expenditures; the decreases in laboratory use were greatest among "high-cost" physicians.

116. Wennberg JE, Blowers L, Parker R, et al: *Changes in tonsillectomy rates associated with feedback and review. Pediatrics* 1977; 59:821-826

Statewide monitoring of tonsillectomy rates showed there to be a 13-fold difference among 13 geographic regions of Vermont. Feedback of these data to surgeons in the different regions was accompanied by a substantial decline in tonsillectomy rates, especially among the regions previously showing the highest surgical rates.

117. Werner M, Brooks SH, Wette R: *Strategy for cost-effective laboratory testing. Human Pathol* 1973; 4:17-30

This theoretical overview outlined ways to improve the clinical usefulness of laboratory information, including (1) assessing the diagnostic,

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rather than technical, efficacy of laboratory procedures, (2) including the costs of false positives, false negatives and late results and (3) improving test interpretation by physicians.

118. *Williamson JW, Alexander M, Miller GE: Continuing education and patient care research—Physician response to screening test results. JAMA 1967; 201:118-122*

This early study indicated that physicians often fail to respond to unexpected abnormal results of screening tests. Notifying physicians of these findings had no impact on their attention to screening test abnormalities. However, obscuring abnormal results with opaque fluorescent tape made physicians attend to screening test results.

119. *Zuidema GD: The problem of cost containment in teaching hospitals: The Johns Hopkins experience. Surgery 1980; 87:41-45*

The ongoing experience with an aggressive cost control program in a major teaching hospital was described in this report. Elements of the program included (1) decentralizing the hospital management into a series of separately functioning department units, (2) reporting radiology, pharmacy and laboratory usage to the directors of each unit on a monthly and year-to-date basis and (3) sending copies of patient bills to attending staff and house staff monthly. Relatively low cost but high volume items accounted for most of the costs of clinical resources.